

# Manufacturing Readiness Levels (MRLs)

## for Multi-Dimensional Assessment of Technology Maturity

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**U.S. AIR FORCE**

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# Outline



- **Why MRLs?**
- **What are MRLs?**
- **MRL implementation plan**
- **Status**
- **ACAT pilots**



# Why MRLs?

## Manufacturing & Industrial Base Challenge



- Consensus among Congress, OSD, CSAF, GAO:  
*“Advanced weapon systems cost too much, take too long to field, and are too expensive to sustain”*
- Recent GAO study of 54 weapons programs:
  - Core set of 26 programs: RDT&E costs up by 42% and schedule slipped by 20%
    - \$42.7B total cost growth
    - 2.5 years slip on average
  - Characteristics of successful programs (GAO):
    - *Mature technologies, stable designs, production processes in control*
    - *S&T organization responsible for maturing technologies, rather than program or product development manager*
- Defense Science Board evaluated ManTech roles/impacts for AT&L
  - ManTech can significantly impact across all acquisition phases
  - Facilitates manufacturing/industrial base readiness for S&T transition and acquisition



# Technology Readiness Levels (TRLs)



Provide a common language and widely-understood standard for:

- Assessing the *performance maturity* of a technology and plans for its future maturation
- Understanding the level of performance risk in trying to transition the technology into a weapon system application

TRLs leave major transition questions unanswered:

- Is this level of performance reproducible in items 2- 1000?
- What will these cost in production?
- Can these be made in a production environment by someone without a PhD?
- Are key materials and components available?



# Manufacturing Readiness Levels (MRLs)



## *What are MRLs?*

- Framework to evaluate “*manufacturing maturity*”
- Complements existing Technology Readiness Levels
- Used to assess maturity and risk of a technology’s underlying manufacturing processes
  - Enable rapid, affordable transition to weapon system programs
- Designed to address manufacturing risk mitigation



# DoD MRL Implementation



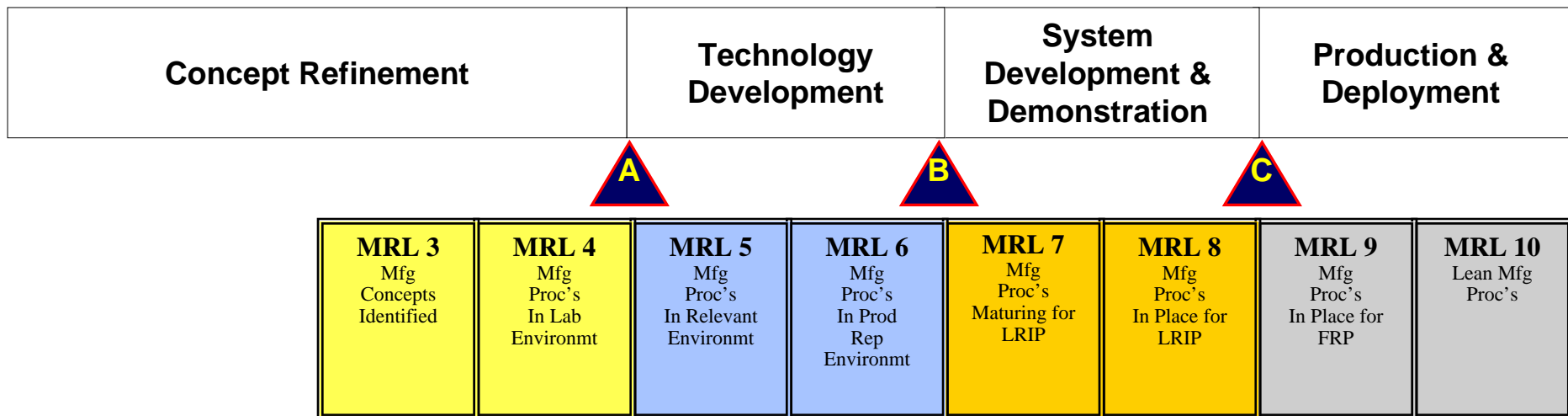
- **DoD (AS&C) vision is to develop and institutionalize MRLs**
  - Assess the manufacturing maturity of a technology or product and plans for its future maturation; common language to convey status
  - Understand the level of manufacturing risk in trying to produce a weapon system or transition the technology into a weapon system application
- **DoD Joint Defense Manufacturing Technology Panel (JDMTP) chartered an MRL Working Group to refine definitions and develop plans to institutionalize MRLs within the AT&L community**
  - Government and industry representatives participating
  - Developed definitions that interface with TRLs and milestone decision points
  - Develop implementation strategy consistent with DoD 5000 acquisition doctrine, practice, and milestone decision points
- **SAF/AQ**
  - Conduct ACAT pilots and then develop policy
- **AFRL/CD**
  - Implement into all AFRL ATDs



# MRL Relationships



## *Relationship To System Milestones*



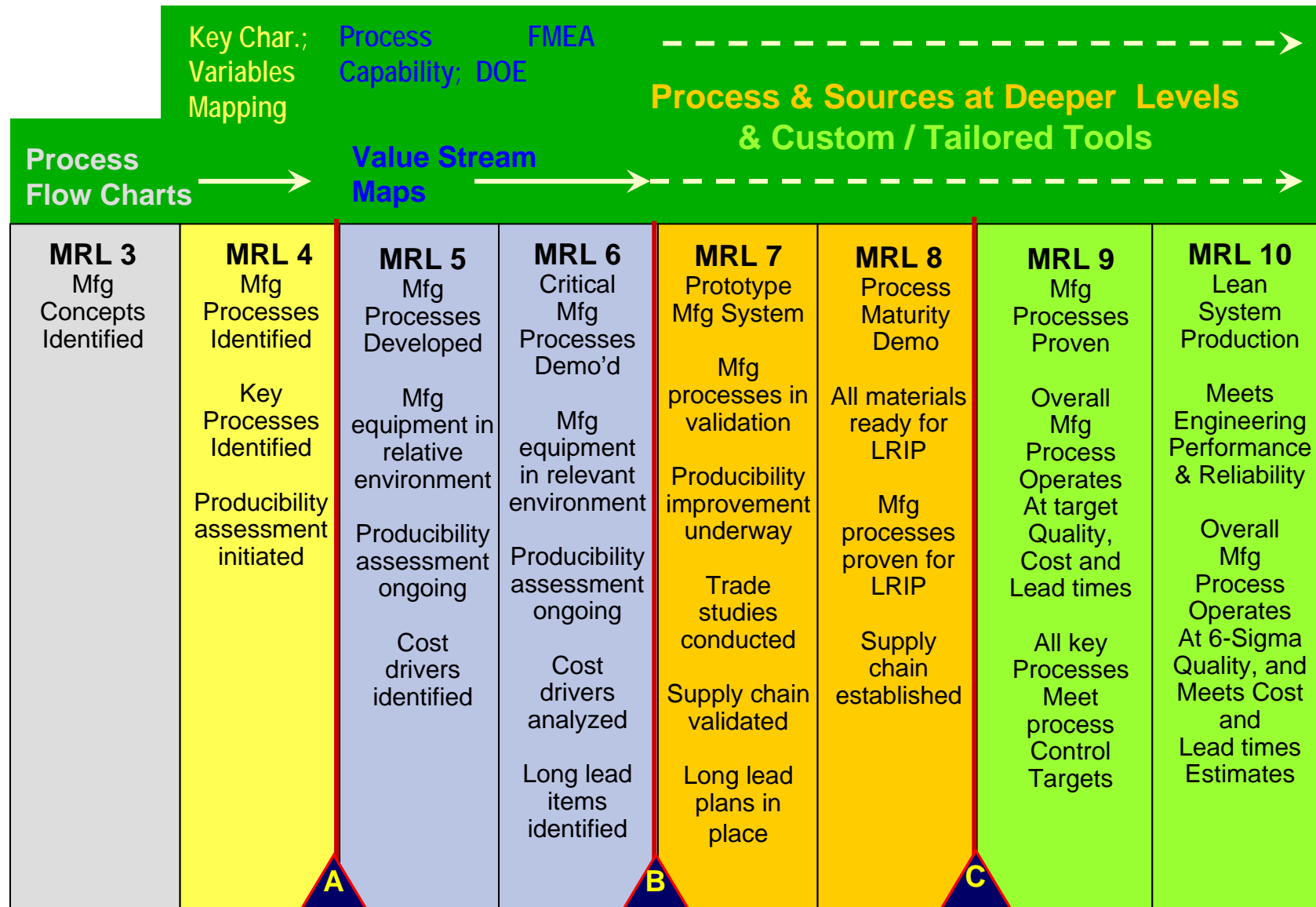
## *Relationship To Technology Readiness Levels*

<b>TRL 1</b> Basic Principles Observed	<b>TRL 2</b> Concept Formulatio	<b>TRL 3</b> Proof of Concept	<b>TRL 4</b> Breadbrd in Lab	<b>TRL 5</b> Breadbrd in Rep Environmt	<b>TRL 6</b> Prototype in Rep Environmt	<b>TRL 7</b> Prototype in Ops Environmt	<b>TRL 8</b> System Qual	<b>TRL 9</b> Mission Proven
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# MRL Definitions & Tools





# Mapping Tools for MRL



<u>MRL</u>	<u>Tools</u>	<u>Use to Evaluate...</u>
<b>3</b>	<b>Process Flow Charts</b>	<b>Basic manufacturing concepts</b>
<b>4</b>	<b>Detailed Process Flow</b>	<b>Key manufacturing processes charts</b>
<b>5</b>	<b>Value Stream Mapping and identifying waste</b>	<b>Mapping the current state</b>
<b>6-10</b>	<b>Value Stream Mapping and eliminating waste</b>	<b>Mapping the future state</b>



# Process Control Tools for MRL



<u>MRL</u>	<u>Tools</u>	<u>Use to Evaluate...</u>
4-6	Key Characteristics	Requirements and tolerances
4	Process Variables Map	Which variables to control
5-9	Process Capability Performance	Predictability of process
5-9	Design of Experiments independent variables	Multiple factors and levels of
6-9 Analysis	Failure Modes and	Risks associated with failure effects



# MRL Evaluation Criteria



- **Technology and Industrial Base**
- **Design**
- **Materials**
- **Cost and Funding**
- **Process Capability and Control**
- **Quality Management**
- **Manufacturing Personnel**
- **Facilities**
- **Manufacturing Management**



# What is an ATD?



- Any Air Force science and technology program (6.3)
  - Objective of demonstrating an integrated set of technologies
    - Superior warfighting capability
    - Ready to transition before the end of the FYDP
- Sufficiently mature the technology(ies) for transition into an advanced system development or a fielded system upgrade
- Categories
  - CAT 1
    - MAJCOM/Agency supports and has programmed required funding for transition within the FYDP
  - CAT 2A
    - MAJCOM/Agency supports and is committed to identify transition funding in next programming cycle
  - CAT 2B
    - MAJCOM/Agency supports but is not currently able to POM for transition



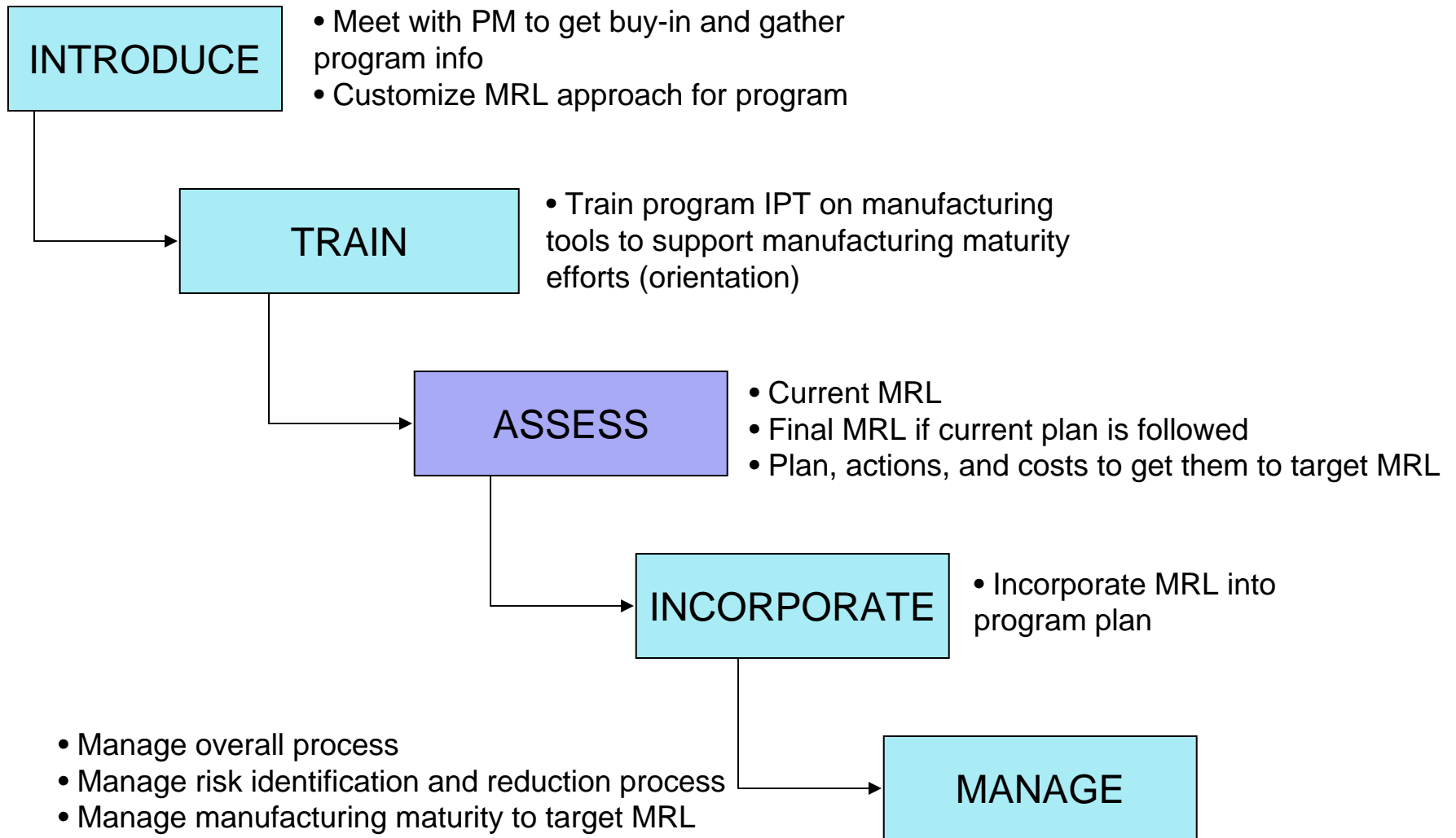
# **MRL Incorporation into AFRL ATDs**



- **Conducted ATD pilot assessments on five ATDs**
- **Tasked to implement MRLs into hardware intensive ATDs**
- **Developed basic approach/process for implementation**
- **Developed training for ATD IPTs and ManTech personnel**
- **Identified core ManTech funding for MRAs and selected follow-on MRL maturation**
- **Conducted assessments of four additional ATDs**
- **Currently working with ten total ATDs**



# ATD MRA Approach





# Current ATD Portfolio



- **F135 (PR)**
- **F136 (PR)**
- **Common Weapons Data Link (MN)**
- **X-band Thin Radar Array (SN)**
- **Shredder (MN)**
- **High Temperature Polymeric Matrix Composites (ML)**
- **High Durability Hot Exhaust Structures (ML)**
- **Affordable Responsive Space Lift (VA)**
- **Battlefield Air Operations Kit (MN)**
- **Advanced Multi-junction Solar Cells (VS)**





# Manufacturing Readiness Current Planning Process



- **ATD selection has been by TD**
  - **Primary Customer Base, CAT I ATDs**
    - **PR, SN, MN, VA, VS, and ML**
    - **Implement MRLs into five ATDs per quarter**
  - **Introduced MRLs to wide AFRL community**
- **Training ManTech personnel to conduct effective assessments**
- **Train IPT, conduct assessment, execute plan to reach target MRL**
- **Developing process with AFRL/XP for timely new ATD identification**
  - **ManTech to become an integral part of ATD selection process**



# ATDs Planned for FY06



- Choose ATDs based on similar technologies areas
- ATD candidate technology areas
  - Electronics
  - Propulsion & Power
  - Space
  - Structures
- Identify cross-cutting technologies
  - Develop ManTech program to satisfy several ATDs
  - Leverage on-going programs
- Planning a summer blitz to implement into several ATDs



# FY06 ACAT Tactical Plan



- **Per SAF/AQ tasking, select pilots with SAF/AQR**
  - **Need to manage with on-going ATD workload**
- **Convene experienced assessment team**
  - **Experience with assessment process**
  - **Subject matter expertise**
  - **Acquisition wing personnel and contractors**
- **Conduct MRAs on pilots – key technologies or components**
  - **E.g. F-22A, AMRAAM**
- **Develop/refine assessment process for acquisition programs**
  - **Will vary from ATD process and may be program specific**
  - **Dependent on current or target milestone**
  - **Significant program office involvement**



# MRA Deliverables



- **Current MRL**
  - **Key risk areas**
  - **Driving issues**
- **Plan to obtain target MRL**
  - **Risk mitigation plans**
  - **Schedule**
  - **Funding**
  - **Contract modification language**



# Additional Information



- MRL definitions can be found at DAU web site:
  - [https://acc.dau.mil/simplify/ev\\_en.php](https://acc.dau.mil/simplify/ev_en.php)
    - Click on Production Quality & Manufacturing
    - Click on Manufacturing Readiness Assessments



# In Closing



- **MRL working definitions established**
  - **JDMTP on board**
  - **Exercising on ATDs and ACATs**
  - **But no formal policy yet**
- **MRL process established in AFRL ATDs**
- **Managing current manpower issues**
- **Initializing ACAT pilot efforts**

***Moving forward but still developing...***